Municipal Affairs and Housing | Energy
Ontario

A Housing Energy Management Program Report

Energy
Ontario

FUNCTIONAL TESTING OF A DUAL COMPRESSOR HEAT PUMP

INSTALLATION AND INTERIM REPORT

REPORT No. 7A

Prepared for
Ontario Ministry of Municipal Affairs and Housing
Technical Services Division
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by

THE CONSUMERS' GAS COMPANY LTD.

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1.0 INTRODUCTION

The energy industry has to remain fully informed on technological developments, with respect to new utilization equipment, as manufacturers continue their research efforts to improve the reliability, performance, serviceability and the final cost of their products.

The Ministry of Municipal Affairs and Housing and The Consumers' Gas Company Ltd. agree that new products should be evaluated in the field, to confirm manufacturers' claims and to assess the functional ability of the appliances. A cooperative program was agreed on to examine a new market entry residential space conditioning system.

The product selected, which is commercially available, is a second generation of high-performance heat pump, which has two compressors, both of which are housed in a single sound-proofed container. The dual compressor package is installed indoors to avoid the detrimental effects of weather and the wide ambient temperature swings which conventional heat pump compressors are normally subjected to, in the Canadian climate.

For the purposes of this test, one preproduction, second generation, dual compressor, high-performance heat pump system is installed in a residence in order to obtain functional performance information on the new design. This interim report on the field evaluation is not an "in-depth" study on the economics or the energy performance of the product, but rather an

evaluation of the ability of the unit to perform in a manner which is acceptable to the consumer. Energy savings and the range of fuel costs achieved in this specific installation, may be addressed in the final report.

This report contains information on the equipment under test, covers the installation, and comments on the product and the functional ability of the dual compressor heat pump system to date.

2.0 OBJECTIVE OF TEST

The objective of this evaluation is to determine the functional reliability and operational performance of a new design of heat pump, which has been marketed only recently.

3.0 DESCRIPTION OF HEAT PUMP SYSTEM UNDER EVALUATION

The appliance under test is a dual-compressor split-system heat pump comprising three separate and distinct individual sections; the compression control unit, the indoor section and the outdoor section. The indoor and

outdoor sections are essentially fan-coil units and the heat pump is best described as a tri-split system.

The pump is available as either an all-electric system or as an "add-on" system. The all-electric system uses electric elements for supplementary heat whereas the "add-on" system uses the existing furnace to supply the supplementary heat.

The all-electric heat pump completely replaces the existing space conditioning system and in this configuration the home may require that the existing electrical system be upgraded in capacity in order to handle the much higher electrical load.

An "add-on" system is chosen for this evaluation. Either system is made up of the three components, the compressor control unit, the indoor section and the outdoor section.

The compression control unit which is a relatively small, sound-insulated cabinet, 633 mm wide, 411 mm deep and 587 mm high, weighing approximately 100 kg, contains a low-pressure compressor, nominally rated at 8.5 kW, a high-pressure compressor, nominally rated at 10.5 kW, plus an accumulator and a reversing valve. The reversing valve is activated for changing from the heating to the cooling mode or vice-versa. The system control wiring is also housed in this component.

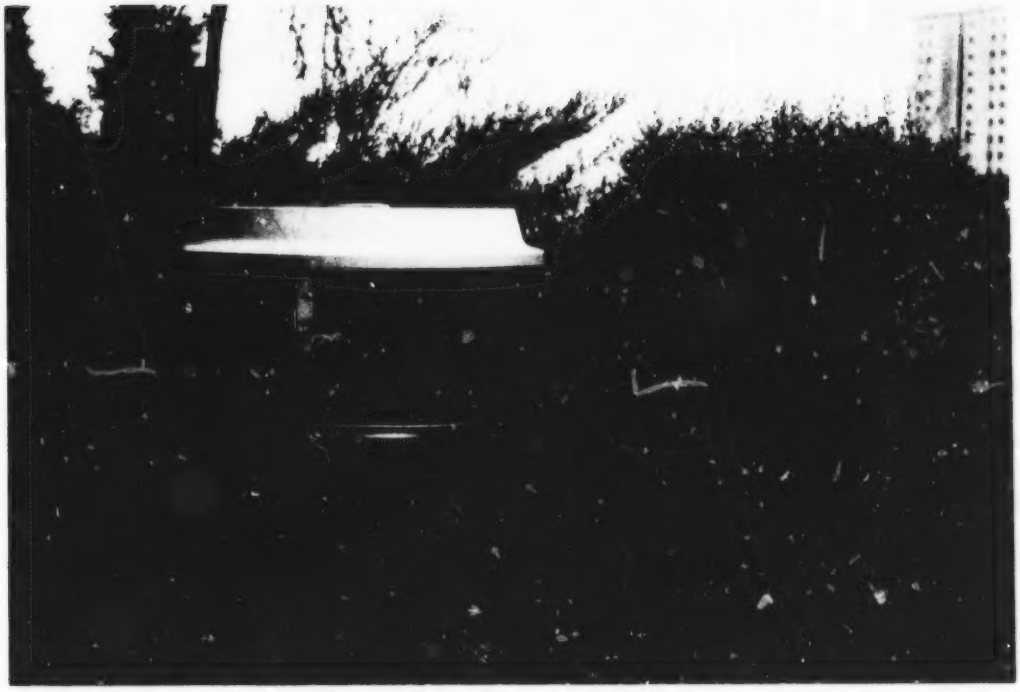
The indoor section of the all-electric unit is 1,422 mm high, 673 mm deep and 533 mm wide and is simply a box containing a refrigerant A-coil, a blower with a multi-speed motor and the electric elements for supplementary heating. In the "add-on" configuration, only the A-coil is supplied which is installed in the existing plenum and the existing furnace blower is utilized to move the air around the home.

The outdoor section is a cylinder of 438 mm diameter and 812 mm high containing a wrap-around fan coil and a propeller type direct-drive, high-air volume, low speed fan. The outdoor unit is often mounted on a stand to prevent the ingestion of snow or it can either rest on the ground directly or on a patio stone base (See Figure 1). The approximate weight of the unit is 50 kg.

In addition to the three separate major components, the pump is supplied with thermostats, an emergency heating relay, compressor protection and an optimiser control, which automatically switches the system to the most efficient mode of operation, either heat pump or supplemental heating, through the use of an outdoor preset temperature controller.

This multiple package provides unmatched versatility, as it can have as an option, built in provision, to enable the normally wasted heat carried by the hot refrigerant to be utilized to produce domestic hot water in the summer months when the unit is operating in the air-conditioning mode. The unit under test does not have the domestic hot water tank option.

FIGURE 1



OUTDOOR SECTION OF DUAL COMPRESSOR HEAT PUMP

The manufacturer claims that the system under test has a Coefficient of Performance (COP) in the range 2.7 to 2.9 in heating, as determined in accordance with ARI Standard 240-77-270/75. Defrost activation on this unit is designed to operate on demand.

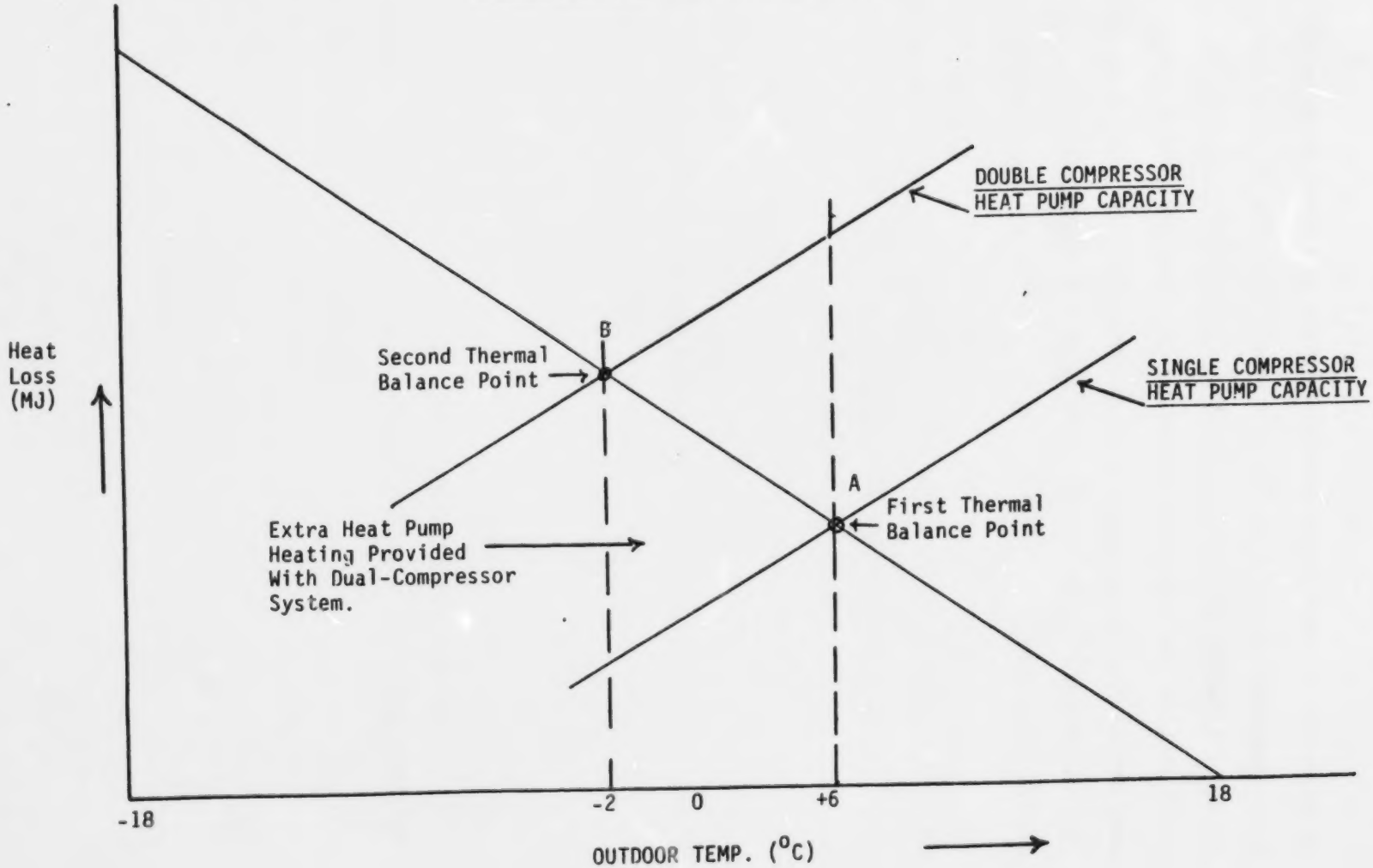
4.0 OPERATION OF THE DUAL COMPRESSOR HEAT PUMP

While the operation of this heat pump is not complex it is a complicated piece of hardware, differing from other residential heat pumps by virtue of the two-compressor design. Because of this it becomes more suitable for areas which have prolonged cold winters. In a conventional, single compressor heat pump, a thermal condition, known as the balance point, is reached whereby the heat pump cannot supply sufficient heat to meet the demand of the residence, and supplementary heating of either electrical resistance type or the combustion generated type is required to satisfy the residential heat demand.

The presence of the second compressor in the dual compressor system establishes a second thermal balance point and more heat is made available than otherwise would be available from a single compressor conventional unit. In areas where the annual degree days are above 3000°C this system is advantageous. The operation is shown graphically in Figure 2.

FIGURE 2

GRAPHICAL ILLUSTRATION OF
DUAL COMPRESSOR BALANCE POINTS



In operation, if the outdoor temperature drops to a level at which the first compressor can no longer deliver enough heat (the first balance point), the second compressor is energized automatically to meet the residence heat loss. Once the second balance point has been reached, supplemental heating is required. In essence, the dual compression feature increases the ability of the heat pump to provide indoor warmth at lower outside temperatures.

5.0 INSTALLATION

A large home located in Caledon East is being utilized as the test site. The residence is a detached four level side split home with brick veneer cladding and aluminum siding. The useable floor area is 167 m². The home is shown in Figure 3 and described in more detail in the homeowner questionnaire, Appendix I.

In this particular test location the original furnace is retained with the A-coil of the heat pump being located in the supply plenum above the existing gas-fired furnace heat exchanger, and the heat pump is installed as an "add-on" type. The acoustically lined dual compressor section is located adjacent to the furnace and the outdoor section is located close to the rear house wall nearest to the furnace room, in an attempt to keep the length of the refrigerant line set to a minimum.

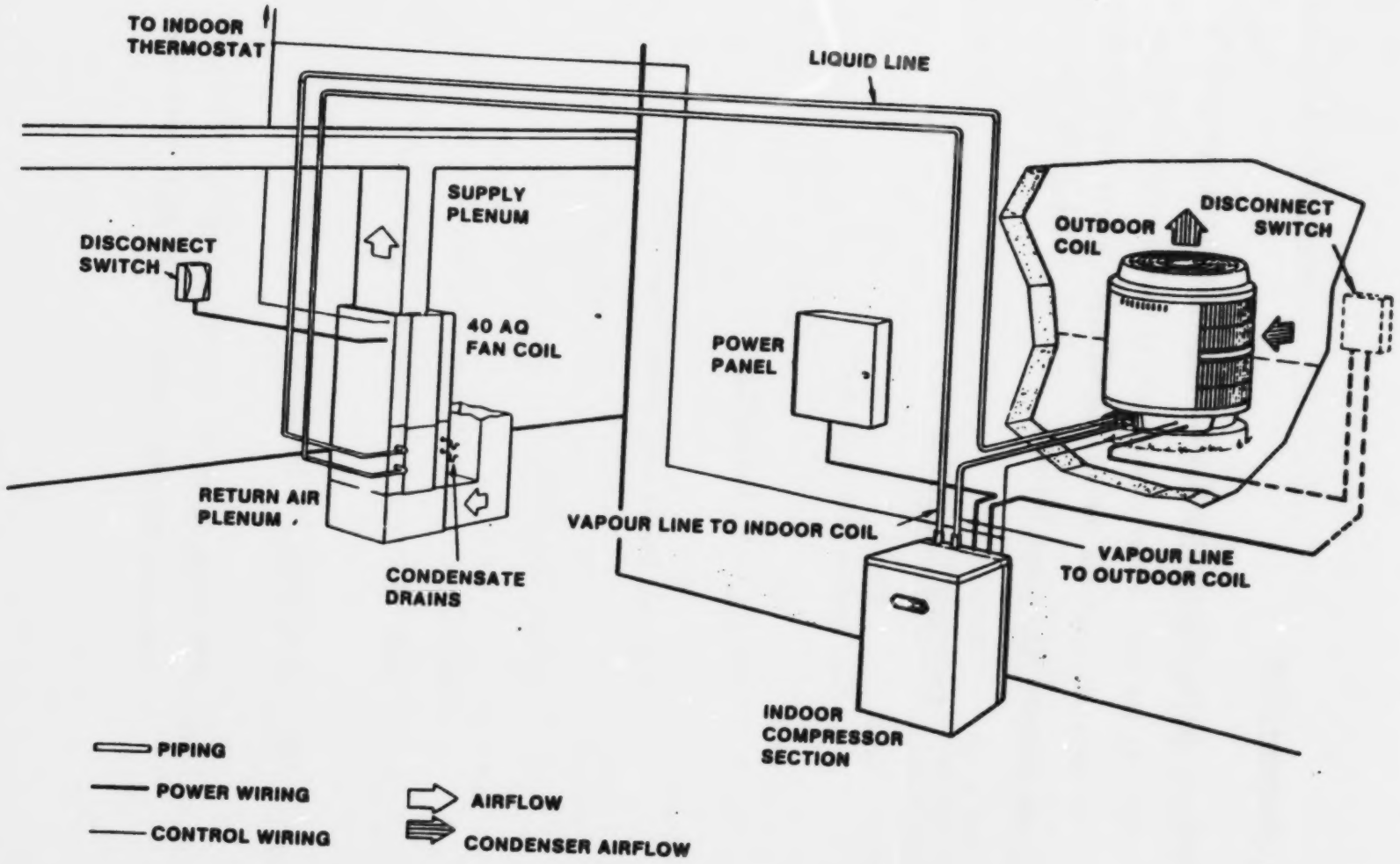
The system is shown diagramatically in Figure 4.

The installation of this unit was conducted by an approved heat pump contractor. No difficulties were encountered and the work was completed in one day in a professional manner.

FIGURE 3

EXTERNAL VIEW OF TEST HOME

FIGURE 4



SCHEMATIC OF INSTALLATION SHOWING COMPONENTS

5.1 Instrumentation

Sufficient, but unsophisticated instrumentation is installed to indicate the total energy consumptions of both the heating systems, the operating times and the site degree days. A brief description of the instrumentation used follows:

5.1.1 Gas Energy Consumption

One Canadian Meter type A-225.

5.1.2 Electric Energy Consumption

A Sangamo demand type in the range 2-200.

5.1.3 Running Hour Meter

Kessler-Ellis Products type ETH16.20, 24 volt, 60 Hz, supplied through Power Service Products, Toronto.

5.1.4 Site Degree Day Recorder

Hidy-Brown degree day recorders, supplied through the Hidy-Brown Recorder Company, Hilton Head, North Carolina.

5.2 Installation Costs

The costs incurred to install and instrument this system are shown below:

MATERIALS

	Estimated Cost As Installed For This Field Evaluation	Estimated Cost For A Typical Residential Installation
Heat Pump	$3,000	$2,800 - $3,000
Contractor Supplied	590	Not required
Thermometers	96	in a typical
Degree Day Recorder	1,024	or conventional
Meters	143	Heat Pump
Miscellaneous Fittings	70	installation.
Other Sundry Supplies	100	100 100
Sub Total Materials	$5,023	$2,900 - $3,100

LABOR

	Estimated Cost As Installed For This Field Evaluation	Estimated Cost For A Regular Residential Installation
Contractor	$1,003	$1,000 - $1,500
Electrical	250	Normally included in contractor price in a conventional installation
Sub Total Labor	$1,253	$1,000 - $1,500
Total (Labor & Materials)	$6,276	$3,900 - $4,600

The above is the estimated cost to install the system as set up for experimental purposes and includes instrumentation and other components.

The average householder contemplating the installation of this particular model heat pump as a normal retrofit in the add-on mode would expect to pay in the $3,900 - $4,600 range.

6.0 COMMISSIONING TRIALS AND OPERATION

The system was first put into operation during the latter part of March 1982 and it operated for a period of three days before a persistent frosting up of the outdoor unit developed. The system was unable to defrost and had to be shut down for examination, which revealed that either the accumulator or the capacity of the refrigerant line set connecting the outdoor unit to the compressor may have been too small. The accumulator was replaced but the system continued to experience further difficulties over the month of April, specifically with compressor noise and malfunction, such that no usable data were accumulated because of the intermittent operation.

Eventually the compressor unit was returned to the factory for examination and rectification. The unit was refurbished and returned but too late in the season to allow further heating mode data to be collected. Finally, the unit was set in the air-conditioning mode for the summer of 1982.

7.0 INTERIM COMMENTS ON THE SYSTEM

Most heat pump systems are more complex than a regular furnace and homeowner understanding of a heat pump is necessary for the correct operation of the system. It would assist if contractors/installers would

discuss the system and coach the homeowner on its use prior to leaving the premises. This particular heat pump experienced a significant number of apparent design defects, a feature not uncommon when a new model is introduced into the market for the first time. Examination and analysis of the 1982/1983 heating season data should allow adequate comment on the performance ability of the system. The unit, subsequent to the initial difficulties, appears to provide adequate comfort levels and the homeowner has made no detrimental comments.

Although first cost is bound to be a major consideration, a homeowner contemplating the purchase of a heat pump needs to consider whether to select a system with the compressor set outdoors or indoors, whether single-speed, two-speed or dual compressors are appropriate and whether the unit has a timed defrost cycle or a demand defrost cycle. The determination of some of these aspects is another of the reasons for this evaluation.

Data on this system are to be collected weekly with weekly changeovers, but so few readings have been taken because of the downtime that insufficient information has been gathered to draw any firm conclusions on the energy requirements of the system. A typical data collection sheet is shown in Appendix II.

8.0 INTERIM CONCLUSIONS

(a) The comfort level in the residence during the period when the heat pump operated was acceptable to the homeowner.

(b) Functional reliability of this new model of heat pump is suspect, but this condition is understandable although not desireable since this may be expected of any new product introduced into the marketplace for the first time.

9.0 INTERIM RECOMMENDATION

The field evaluation continues with the refurbished unit over the next heating season.

APPENDICES

APPENDIX I
HOMEOWNER QUESTIONNAIRE

GENERAL INFORMATION

Name of occupant Bruce L. Shaw

Installation address Caledon East

Single Family Residence? Yes Multiple? _____

Approx. age of structure 10 years How long have you resided? 4 years

No. of occupants 4 Adults 2 How many are employed 1

If two or more, which hours _____

What indoor temperatures do you maintain:

While at work 22.5°C Hours _____

Daytime 22.5°C Hours _____

Nighttime 22.5°C Hours _____

STRUCTURE

Do you have a basement Yes Is it heated Partially

Number of stories 4 level side split

Type of construction (Brick or frame) Brick

Does it have storm windows Yes Storm doors Yes

Is it insulated Yes Was any insulation installed recently No

If so, when _____ Where, and thickness _____ Type _____

In your opinion, is building of tight construction No

No. of basement windows 2 Do they close tightly Yes

Is the door to the basement normally closed No

No. of exhaust fans: Kitchen None Bathroom None Other None

Where is thermostat located (room) Kitchen Inside or Outside wall Inside

Does this house have a fireplace Yes Does it have a good damper Yes

How often is it used? 5 times/yr.

Chimney height 6 m No. of flues 1 Internal dia. of each flue _____

No. of openings in chimney 1

Does it have a cleanout door inside or outside No

APPENDIX 1
Homeowner Questionnaire, page 2.

APPLIANCES

Does this residence have a gas light No

Input or number of mantles _____

Does this residence have an electric or gas range Electric

If gas: Type _____ Location _____

Does this residence have a gas grill _____

Hourly inputs _____ How often is it used _____

Does this residence have a gas or electric clothes dryer No

If gas: Location _____ Vented to outdoors? _____

Size of vent pipe _____ Hourly input _____

How often is it used _____

Does this residence have a gas fired water heater Yes

Storage capacity Typical Rental unit Hourly input _____

Size of flue pipe _____ Does this pipe connect to the same chimney as the heating system. Yes

Does this residence have air conditioning Yes - Heat Pump

Central Heat Pump Window units _____ How many? _____

HEATING SYSTEM

Present Furnace.

Trade Name Chrysler - Airtemp

Model _____

Manufacturer Chrysler

Rated Input 26.36 kW

Age 10 years

Type of Ignition Standing Pilot

Type of Venting Non-power

Test Appliance.

Trade Name Weather Master Heat Pump

Model III

Manufacturer Carrier

Rated Input (Heating COP 2.7 - 2.9)

Age _____

Type of Ignition _____

Type of Venting _____

rd3/a

APPENDIX II
DUAL COMPRESSOR

HEAT PUMP FIELD EVALUATION

Date March 1982	Electric Meter Reading Heat Pump (kW x 20)	Gas Meter Reading Furnace (Ft. x 10)	Top Hour Timer Hours (Accumulated)	Bottom Hour Hour Timer Hours (Reset Daily)	Degree Days (°F)	Supply Temp. (°F)	Return Temp. (°F)	Mode HP	Mode GF	Remarks
21	0121	7875	01088.5	0000.0	00000			X	X	A.M. Warm-up on Gas
22	0122	7885	01098.9	0010.4	00033				X	
23	0122	7911	01102.6	0003.7	00070			X	X	
24	0124	7918	01116.2	0013.5	00099				X	
25	0124	7959	01126.5	0009.6	00127			X	X	

rd3/aa

POOR

QUALITY

ORIGINAL